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STS-3 Medical Report

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STS-3 MEDICAL REPORT

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FOREWORD

The Space Transportation System Three (STS-3) was the third of the four planned orbital flight tests (OFT) of the Space Shuttle Program. This mission, though longer than planned due to weather conditions at the landing site, was successfully completed on March 30, 1982. The mission demonstrated for the first time the eight-day capabilities of a reusable space vehicle.

The Commander of the mission was Jack R. Lousma, Colonel, U.S. Marine Corps, and the Pilot was C. Gordon Fullerton, Colonel, U.S. Air Force.

The primary objective of the OFT program is to evaluate and demonstrate under progressively demanding conditions the safe ascent, on-orbit operation and return of the Orbiter and crew. In addition to the aerodynamic evaluations, a scientific payload (OSS-1), several experiments (Electrophoresis Equipment Verification Test, Monodisperse Latex Reactor, and Plant Growth Engineering Test) and the first Get-Away Special (GAS) were included in this mission. The medical operations team continued to test and evaluate medical support logistics and evolve concepts for a standardized program to be utilized during the mature STS operations.

The STS-3 mission presented the NASA medical team with a series of operational problems associated with the symptoms of initial vestibular responses to weightlessness and altered work/rest cycles. Medication, altered crew activity plans, and modified fluid and food consumption regimen were prescribed as supportive health maintenance procedures. All phases of the mission required real-time re-evaluation, identification of potential impact on pre-existing medical constraints, and development of appropriate recommendations and solutions. These activities required significant coordination among the different medical operations and mission control teams.

This report is intended to be a detailed medical evaluation of the STS-3 mission.

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INTRODUCTION

The Space Transportation System Three (STS-3) was launched on March 22, 1982, at 15:59:59:785 G.M.T. from Kennedy Space Center, Florida, for a planned duration of seven days. The mission was originally planned for a landing at Edwards Air Force Base, California, but due to adverse (wet) lake bed runway conditions, the primary landing site was moved to White Sands, New Mexico. Again, adverse weather conditions changed the plan. This time blowing dust caused the delay of landing by one day. The Orbiter landed satisfactorily on the eighth day at 16:04:46 G.M.T., March 30, 1982. The crew for this third orbital flight test was Colonel Jack R. Lousma, Commander and Colonel C. Gordon Fulletrton, Pilot.

The major activities of the STS-3 flight were the thermal testing and remote manipulator system (RMS) testing which also had thermal aspects to it. The major thermal testing consisted of placing the Orbiter in four central attitudes for extended periods of time to determine the thermal responses of specific areas. These attitudes were tail-to-sun in orbital rate, nose-to-sun twice orbital rate, top-to-sun solar internal, and passive thermal control. Temperatures in the tail and nose-to-sun attitudes were maintained within required range with heater duty cycles less than predicted because of slower thermal responses as demonstrated on STS-1 and 2. All payload bay door closure during the various attitudes were successful except during the tail-to-sun attitude. This situation was cleared after reorienting the Orbiter to the top-to-sun attitude for approximately 15 minutes followed by a short period of passive thermal control.

Approximately 48 hours of RMS testing were completed during STS-3. The major compromise to the RMS tests was caused by the loss of the wrist TV camera. This loss prevented the development of the induced environment contamination monitor (ICEM), therefore the plasma dynamics package (PDP) was used in the IECM's stead. The PDP weighs about 500 pounds less than the IECM, thus reducing the effectiveness of the dynamic data.

All spacecraft systems operated satisfactorily throughout the STS-3 mission with only minor problems that did not impact the conduct of the mission.

EVALUATION OF CREW HEALTH

Craig L. Fischer, M.D. and James M. Vanderploeg, M.D.

PRE-FLIGHT INTERVAL

The F-30, F-10 and F-0 pre-flight physical examinations were conducted on schedule and were essentially normal. The only pre-flight medical problem presented was an apparent upper respiratory infection, experienced by one of the crewmen.

From a laboratory perspective, this crewman exhibited an absolute neutropenia and relative lymphocytosis on F-10, associated with a minimal rise in the ZSR. By F-2, the absolute neutropenia was remitting. These laboratory data, plus a negative throat culture for bacterial pathogens, when integrated with the presenting clinical symptoms of mild nasal congestion, injected throat and afebrile state strongly suggest a viral etiology for the upper respiratory infection. Other pre-flight laboratory data of this crewman were remarkable with respect to the Alk-Phos and SGOT (AST) results. These enzymes showed a minimal and transient rise on F-2, unassociated with changes in the SGPT (ALT) and GGTP values. In addition, no increase in the slow zone LDH isoenzyme activity (liver related) was noted during this interval. Because of the small magnitude of the Alk-Phos and SGOT enzyme elevations and their disassociation with other sensitive hepatobiliary and liver parenchymal enzyme markers, statistical variations rather than clinical liver disease must be implicated.

On flight morning, both the Commander and Pilot were in excellent physical and mental status.

POST-FLIGHT INTERVAL

Because of weather conditions, the landing was moved to Northrup Strip, New Mexico. The Crew Physician entered the Orbiter approximately 10 minutes after wheel stop. Upon entering the mid-deck, specific notice was made of any odors emanating from the spacecraft. There were none. The atmosphere within the Orbiter was odorless. The Crew Physician ascended the ladder from the mid-deck to the flight deck and found both Commander and Pilot sitting, with helmets off, in their respective seats. Both men were smiling and in no obvious distress. Their comments were spontaneous and appropriate. The Commander then egressed his seat and at the surgeon's request checked all the switch positions and associated connectors of the bio-med sensors. No anomaly was found. He then descended, without difficulty, to the mid-deck. He stated he felt "heavy and had light-headedness", but upon questioning the lightheadedness was more an unsteady sensation and was unassociated with clinical symptomology. He did not experience vertigo at any time. The Commander also stated he was somewhat warm and thirsty. He was offered an oral electrolyte solution and drank approximately 700 cc over a period of 2 minutes while standing on the mid-deck.

By this time the Pilot had descended the ladder from the flight deck to the mid-deck and the Commander moved to the white room just outside the Orbiter's hatch. The Pilot mentioned he was also thirsty and consumed an estimated 100 cc of the oral electrolyte solution over a period of one minute. Subsequently,

the Commander and Pilot walked down the steps from the Orbiter to the desert floor without assistance or difficulty. Once inside the crew van, the suits were doffed and no evidence of excessive perspiration was found in any of the garments. The ride from the Orbiter to the medical examining facility was short and no significant medical problem was encountered. Once inside the medical exam facilities, the crewmen were debriefed according to plan. The physical examinations, including the stand tests, were unremarkable. Following the examinations, the crew consumed more of the oral electrolyte solution, with the Commander drinking an overall total of 816 mls and the Pilot 203 mls. These totals include the amount consumed on the Orbiter.

The post-flight laboratory data revealed an expected, absolute neutrophilia demonstrated by both the Commander and Pilot. This finding reverted to normal range by the L+3 examination and may be attributed to an epinephrine response. The Commander and Pilot both showed minimal elevations in serum creatinine, unassociated with an increased BUN or uric acid. The Pilot exhibited a modest increase in Alk-Phos post-flight, which was unassociated with an increase in the GGTP, therefore suggesting bone origin. This modest post-flight increase returned toward normal by L+3. The Pilot also showed a transient and minimal elevation of the total LDH at L+0 which slowly fell towards normal by L+10. Review of the Pilot's pre-flight LDH data reveals near equality and actual reversal of the LDH 1:2 ratio during the pre-flight interval. The post-flight data showed no major departure from the previously established pattern. No significant alterations in the CPK totals or isoenzymes patterns were recognized in any time interval.

In summary, no significant health problem was detected in the post-flight interval.

INFLIGHT MEDICAL OBSERVATIONS

Michael W. Bungo, M.D.

The approach to inflight medical assessment and care for STS-3 was the same as that described for earlier Shuttle flights in documents similar to this one. In short, a private medical conference was held daily between the crew and the Mission Operations Control Room (MOCR) Surgeon.

Launch occurred at 16:00 GMT on March 22, 1982. The first private medical conference (PMC) was held 7 hours and 20 minutes into flight. At that time, the pilot (PLT) reported he was "feeling great". The commander (CDR), however, reported that he began to have space motion sickness symptoms at the time of OMS-1 (about 19 minutes into the flight). He took a Scope/Dex capsule at that time and a second dose 4 1/2 hours into the flight. Within 1/2 hour after this second dose and having been moving around for suit doffing, he experienced nausea and vomited once. He was asked to continue motion sickness prophylaxis (Scope/Dex) one capsule approximately every 4 hours while awake and continuing through the second day. The CDR reported that even though his food intake was reduced, he was especially conscious of continuing to consume fluids. Waste water tank levels seemed to be consistent with reasonable outputs. When the PMC was held on the second day, it was obvious that both crewmen were not feeling well. First, they had been awakened multiple times during the night because of static in their headsets as they passed over certain regions of Asia. Secondly, the CDR's appetite was depressed although he had not experienced further episodes of vomiting. Thirdly, the PLT had developed symptoms of loss of appetite and had additionally developed some low back pain which, on further questioning, appeared to be musculoskeletal in origin and similar to problems encountered on prior space flights.

The Mission Control Center flight team subsequently rearranged the crew activities plan (CAP) to switch tasks on mission day 3 for tasks scheduled for mission day 4. This provided an easier day for the crew earlier in the mission so that they might have time to recover from the space motion sickness syndrome. In addition, they were allowed an extra hour of sleep time. Unfortunately, the cabin was reported to be "chilly" during the night which was probably due to the scheduled tests being performed to characterize the Orbiter's temperature response to different attitudes.

The third PMC (24 March 1982, 20:20 GMT) found both crewmen still having symptoms of anorexia and lassitude, but both were improving their functional capacities.

Minor system problems continued to plague the crew such as cool cabin temperatures, drink bottles which had the filling stems broken and jamming of the waste collection system slinger by an emesis bag. On day 6 of the flight (March 27), both crewmen used the passive treadmill supplied for their exercise. Only brief tryout periods were utilized, but they reported promise in its functional capabilities.

During day 7 of flight, the crew was obviously in excellent spirits with no medical residual from their previous symptoms.

Entry was scheduled for the morning of March 29, 1982. As part of the preparation for landing, both crewmembers consumed 1000 cc of an electrolyte solution as a means of increasing their blood volume. On the last revolution of the Earth, however, it was obvious that sand storm conditions would prevent a landing at Northrup Strip, New Mexico, therefore the entry procedure was delayed for 24 hours.

A PMC held the evening of this wave-off day revealed the crew to be asymptomatic and in good spirits. The following morning, they purposely drank additional fluids but no longer had any specific "entry beverage" as they had on the preceding day.

The anti-g suits were prophylactically inflated by both the PLT and the CDR at entry interface minus 6 minutes. No discomfort from the suits or from g forces was reported by the crewmembers. Electrocardiographic data were obtained on the CDR but not the PLT. The cause of this malfunction is not clear as satisfactory data had been obtained from both crewmen during the launch phase and during the aborted landing phase one day earlier.

Touchdown occurred at 16:05 GMT on March 30, 1982. The crew egressed the Orbiter 39 minutes later.

SHUTTLE ORBITAL MEDICAL SYSTEM

James M. Vanderploeg, M.D.

The Shuttle Orbiter Medical System (SOMS-A) is an outgrowth of onboard medical kits which have been in use throughout the history of manned space flight. The STS-1 Medical Report contains a brief summary of previous medical kits and training.

SOMS-A was designed for use during the Orbital Flight Tests to provide treatment capability for life-threatening emergencies and to permit diagnosis and treatment of many less severe illnesses and injuries. The inventory of the SOMS-A is intended to sustain the medical needs of a two-man crew for up to 14 days.

The total system is composed of the Medicine and Bandage Kit (MBK), the Emergency Medical Kit (EMK) and the Medical Checklist of the Flight Data File. A description of the organization of the two medical kits can be found in the STS-1 and STS-2 Medical Reports. The basic organization of the kits was unchanged for STS-3. The Medical Checklist was modified by making the alphabetical and usage lists of the kits' contents a Flight Supplement. This allows changes in medications for the particular requirements of a crew to be made without having to change and reprint the Medical Checklist sections on Emergencies, Laboratory Medicine and Illustrations.

The evaluation of an individual astronaut's sensitivity to any of the drugs present in the medical kit has been a part of premission preparation throughout the history of the space program. Knowledge of any allergic reaction or undesirable side effects to the medical kits contents is imperative for effective health care by the Mission Operations Control Room (MOCR) Surgeons and Crew Physicians.

As was done in the past, a drug sensitivity evaluation was conducted prior to the STS-3 flight. This evaluation was carried out in two segments. First, the health record of each crewmember was reviewed and every medication which he had received either for a clinical indication or for previous drug sensitivity testing was recorded. Any reported reactions or side effects were also recorded.

The second segment of this evaluation involved testing of each crewmember with those medications which were felt to have a high likelihood for use in flight. This testing was scheduled in such a way that no flying was undertaken for 24 hours following the ingestion of any medication. Most of the tests were done in conjunction with flight simulation exercises. Sedatives were taken at home in the evening to evaluate sleep induction as well as alertness the following day. Prior to being issued any medication the crewmember was briefed on possible side-effects and allergic manifestations and on the procedure to follow to obtain emergency medical attention, if needed.

The information gained from the drug sensitivity evaluation was checked against the contents of the SOMS-A. Thus, the physicians made certain that no medications were carried on board to which a crewman was unusually sensitive.

EMERGENCY MEDICAL SERVICES SYSTEM (EMSS)

Norman Belasco

Planning

Planning for the STS-3 Emergency Medical Services (EMSS) utilized an updated STS-1 format. The most significant change implemented for STS-3 was transferring the responsibility of EMSS Coordinator at the Mission Control Center (MCC) from the Chief of the Medical Sciences Division to each Mission Operations Control Room (MOCR) Surgeon on shift. Assignments for EMSS Flight Surgeons at the participating sites were:

*KSC	Crew Physician	Dr. Fischer
	Deputy Crew Physician	Dr. Vanderploeg
	EMSS Coordinator	Dr. Buchanan
	Helo Flight Surgeons	Dr. Bagian
		Dr. Vanderploeg
		Department of Defense (DOD) Flight Surgeon Backup
*DFRF/EAFB	Crew Physician	Dr. Fischer
	Deputy Crew Physician	Dr. Vanderploeg
	EMSS Coordinator	Dr. Hadley (Dr. McBride, alt.)
	Helo Flight Surgeons	Dr. Seddon
		Dr. Thagard
		DOD Flight Surgeon Backup
*NS	Alternate Crew Physician	Dr. LaPinta
	EMSS Coordinator	Dr. Bergman
	Helo Flight Surgeons	Dr. A. Fisher
		Dr. W. Fisher
		DOD Flight Surgeon Backup
*CLS	Search and Rescue (SAR) Rescue forces, local availability	
	DOD Site Responsible Medical Officer - EMSS Coordinator	

*Kennedy Space Center, Dryden Flight Research Facility/Edwards Air Force Base, Northrup Strip, Contingency Landing Site.

Since the STS-3 landing site changed from DFRF to NS and consideration for change again to KSC was being made in real time, the remainder of the related planning aspects are discussed under Results.

Training

In preparation for STS-3, EMSS oriented training was conducted by participating in joint NASA/DOD rescue exercises at KSC, DFRF, and NS. Simulations were held with each of the contingency landing sites (CLS's) located at Rota, Spain; Hickham AFB, Hawaii; and Kadena AFB, Okinawa.

At DFRF and NS the rescue exercises included aided egress modes at landing, for both on-runway and off-runway contigencies (on land). At KSC the exercises included aided egress modes for a landing mishap on the runway and a landing mishap off the runway (in water). For the rescue exercises, detailed scenarios were appropriately coordinated, and live subjects (as planned) were used at KSC for the on-runway landing mishap and for the water rescue. Contact with CLS needed improvement at Rota and Kadena AFB. Hickham AFB responded flawlessly, as required, with all assignments carried out in accord with the initial contact procedures and overall knowledge of communications protocol, although DDMS took action to improve both site's responsiveness.

Results and Discussion

Because of a weather problem and unacceptable lakebed landing conditions at EAFB/DFRF, the decision was made prior to launch to land at NS, End of Mission (EOM).

For EMSS landing coverage, it was decided to deploy the Crew and Deputy Crew Physicians (after launch and Return to Launch Site, RTLS) from KSC directly to NS, positioning Dr. Fischer (Crew Physician) in the convoy crew vehicle and Dr. Vanderploeg (Deputy Crew Physician) at the strip dispensary where the postflight crew physicals are conducted. Helo Flight Surgeons who were in place at DFRF and NS were to remain, as were the Helo Flight Surgeon and DOD Backup Flight Surgeon at KSC (who replaced the Deputy Crew Physician after launch). The EMSS Coordinator for NS remained on station throughout at building 300, WSMR, where the STS-3 EMSS communication console is located. Once the EOM Medical Operations complement was in place at NS, a decision was made for the alternate Crew Physician to remain at NS in position at the strip Operations Communication Center (OCC). The above deployment changes went very smoothly. Additionally, the Holloman AFB Hospital and the William Beaumont Army Medical Center Definitive Medical Care Facility (DMCF) were alerted to the NS landing plan.

Shortly before the planned EOM time at NS, high winds forced a mission extension and possible landing changes that included considerations of a landing at KSC on the hard surfaced Shuttle Landing Facility (SLF).

Accordingly, arrangements were made to support the EMSS adequately should the landing be at KSC. On the 9th day of the mission, EOM occurred at NS as a nominal landing with unaided egress and without need for EMSS implementation.

The ability to redeploy EMSS teams went smoothly and without significant incident attesting to a satisfactory accommodation of required flexibility. All participants were cooperative and responded in a professional manner.

It is apparent that EMSS at landing sites is heavily dependent upon the inclusion of FOD and DOD personnel. At present, within the Medical Sciences Division alone, there is not a sufficient number of qualified Flight Surgeons to staff all the EMSS positions in support of landings when EAFB, NS, and KSC are primary, backup, and secondary sites.

VALIDATION OF PREDICTIVE TESTS AND COUNTERMEASURES FOR SPACE MOTION SICKNESS

Jerry L. Homick, Ph.D.

Background and Purpose

Experience from previous manned space flight indicates that the space sickness syndrome represents a potential threat to the operational efficacy and physical well being of future space flight crewmembers. Because of its complexity and uniqueness this biomedical problem cannot be resolved solely with ground based research. To obtain final and valid solutions it is essential that data be collected systematically on individuals who fly Space Shuttle missions.

A Flight Supplementary Objective (FSO) was developed to initiate this data collection process with the STS-1 and STS-2 missions. A nearly identical FSO (S343) was implemented for the STS-3 mission.

A primary purpose of this FSO was to conduct inflight observations, supported by a series of preflight and postflight data collection procedures, on STS-3 crewmembers in an effort to validate ground based tests which may be predictive of susceptibility to the space motion sickness syndrome. An additional objective was to implement crew testing procedures which would enable acquisition of data to be used in validating motion sickness countermeasures.

Test Description

Preflight

Part of the required crew preflight activity was based on guidelines set forth in NASA's medical operations policy for the prophylaxis and treatment of space motion sickness with anti-motion sickness drugs. This policy states in part that astronauts with a positive history of space sickness or with no space flight experience will be premedicated with a properly selected anti-motion sickness drug. The policy further states that astronauts who have flown in space with no symptoms of space sickness are not required to be premedicated. Any individual who experiences space motion sickness will be administered appropriate inflight treatment with anti-motion sickness drugs. The policy requires preflight side effects screening and efficacy testing with one or more anti-motion sickness medications.

During the preflight period (at approximately F-180 days) each crewmember completed a questionnaire designed to elicit pertinent information regarding past experiences with various types of motion environments and responses to those environments.

Between approximately F-180 and F-160 days, both crewmembers conferred with the STS-3 Flight Surgeon to select a preferred anti-motion sickness medication. The selected medication was administered to them to determine the possibility of any adverse reactions. The drug screening was done under operational conditions (e.g., Shuttle simulator training) and verbal reporting

by the crewmembers was relied upon. Each crewmember's past experiences with anti-motion sickness medications were also considered in selecting the preferred medication for STS-3.

At approximately F-175 days, the crewmembers were each tested one time for susceptibility to experimentally induced motion sickness in the JSC Neurophysiology Laboratory. The standard Coriolis Sickness Susceptibility Index (CSSI) test was used. This procedure requires the performance of head movements while rotating at a constant velocity in a servo-controlled chair. The test was terminated when the crewmembers reached the Malaise III level (8 symptom points) of motion sickness or performed 150 head movements, whichever occurred first. During this test session the crewmembers were instructed on the self-recognition and reporting of motion sickness symptoms. They were also instructed on the use of the microcassette recorder and inflight symptom checklist.

Two weeks after the baseline CSSI test, the CSSI test was repeated on each crewmember to determine the efficacy of orally administered scopolamine plus dexedrine (Scope/Dex) in preventing motion sickness. A second anti-motion sickness drug efficacy test involving transdermally administered scopolamine was conducted with the PLT two months after the Scope/Dex efficacy test. The scopolamine skin patch was administered 16 hours prior to testing.

Inflight

A microcassette tape recorder and symptom checklist was stowed onboard the Shuttle Orbiter. The two flight crewmen were required to use the recorder and checklist during a designated time (pre-sleep period) each mission day to debrief on any motion sickness symptoms or vestibular sensations that had been experienced.

Postflight

Questions pertaining to motion sickness and vestibular sensations were asked of each crewman on L+0 and during the postflight medical debriefing. Two additional motion sickness susceptibility tests were also required postflight. These are the off-vertical rotation test and the sudden-stop test, both of which were to be performed once on each crewman during the L+10 to L+90 time period.

Test Results

The preflight motion experience questionnaire indicated that both crewmembers had a minimal history of terrestrial motion sickness susceptibility. Adequate preflight baseline CSSI test data were obtained on both crewmembers. The results indicated that both crewmembers were moderately resistant to the vestibular stress induced by the CSSI test. Oral Scope/Dex was judged to be effective for both crewmembers, particularly for the CDR. The scopolamine patch was relatively ineffective for the PLT and produced more noticeable side effects than Scope/Dex.

In accordance with the medical operations policy for the prophylaxis and treatment of space motion sickness, both crewmen took one oral Scope/Dex immediately after the OMS-1 maneuver.

Shortly after the OMS-2 maneuver, the CDR egressed from his seat and began to move about on the flight deck and mid-deck of the vehicle. The CDR reported that the movement induced a general malaise including mild nausea. At about 4 1/2 hours into the mission, the CDR took a second Scope/Dex. Approximately one-half hour later, increased movement associated with removing his flight suit, caused the CDR to experience more severe nausea which quickly culminated in a single episode of vomiting. The CDR continued to experience a general malaise and decreased appetite the remainder of mission day 1 and restricted his head and body movements. The feeling of malaise persisted through mission day 2 and gradually subsided by the end of day 3. By mission day 4 the CDR reported feeling normal and had a good appetite. Additional Scope/Dex was used by the CDR on mission days 2 and 3.

It is significant to note that the STS-3 CDR was also the PLT of the 59-day Skylab 3 mission. On that flight he experienced relatively severe symptoms of space motion sickness which persisted through the fifth day of flight. The CDR reported that his symptoms on STS-3 were not as severe or as long lasting as his symptoms on Skylab 3.

Following orbital insertion the STS-3 PLT remained in his seat for a slightly longer period of time than did the CDR. When the PLT first began to move about in the vehicle he experienced dizziness and a vague uncomfortable sense of disorientation. The PLT reported that the sensation was aggravated somewhat by head movements and therefore moved cautiously during most of mission day 1. On mission day 2 and 3 the PLT's overall feeling of well being worsened slightly. He reported having no appetite, a lack of energy and had to force himself to work. On mission day 4 his appetite improved with increased food intake he rapidly improved. The PLT reported that vigorous head movements did not aggravate his lack of well being after mission day 1. In addition to three Scope/Dex capsules taken on mission day 1, the PLT used two Scope/Dex on mission day 2 and one on mission day 3.

CREW CARDIOVASCULAR PROFILE

Michael W. Bungo, M.D.

As in previous Shuttle missions, cardiovascular data were obtained purely in an operationally oriented mode. Simply stated, these data consisted of a pre- and postflight "stand test". This methodology has been described in the STS-1 Medical Report but in short, is a measure of heart rate and blood pressure response as a result of change in orthostatic position. In addition, heart rate data from ECG monitoring was obtained on both crewmen during the launch phase of flight, and heart rate data on the commander (CDR) was obtained during the entry phase of flight. Entry heart rate data on the pilot (PLT) was not obtained because of mechanical failure of the biomedical harness connector.

Ascent heart rates were similar to those reported for previous Shuttle missions and do not warrant numeration in this report. Unique to this flight was that the crew inflated their anti-g suits approximately 6 minutes before entry interface (at least 30 min before touchdown). Because of decreased calf size occurring as a result of adaptation to microgravity, the suit may not have delivered its set compression pressure. Certainly, the effect of g forces clearly indent the heart rate profile data: however, no cardiovascular symptoms were experienced by either crewman.

Similarities between the F-12 and L+3 stand were readily apparent suggesting that readaptation was likely functionally complete by the third day or sooner postflight. Immediately postflight, however, cardiovascular "deconditioning" was in evidence. In spite of volume loads given to both crewmen, the acceleration of heart rate upon standing was obvious. Although the blood pressure responses of each crewman differed, they nevertheless responded in a manner similar to the two groups that have been seen in prior flights. One crewman reacted as a "rigid pipe" system in that the volume deleted state caused both his systolic and diastolic pressure to fall as the standing posture was assumed. The second crewman, on the other hand, narrowed his pulse pressure with a similar drop in systolic pressure but an increase in diastolic pressure to what might be considered "hypertensive" levels.

Cardiovascular profiles similar to previous Shuttle flights were observed in the crew of STS-3. "Stand test" results evoked different responses in each crewman but were consistent with prior experience. There were no clinical symptoms of orthostatic intolerance. The use of the anti-g suit did not prevent the influence of gravity from affecting the heart rate profile. This latter finding may be explained by inappropriate mechanics of the garment or perhaps only a partially protective effect was observed.

BIOCHEMISTRY AND ENDOCRINOLOGY RESULTS

Carolyn S. Leach, Ph.D.

The studies conducted in biochemistry and endocrinology were to provide data which, when integrated with information from other medical disciplines, permit an objective assessment of the individual crewman's health. Additionally, the data collected during the preflight phase of the Shuttle mission provided baseline information for the medical team in detecting and identifying physiological changes which may have resulted from exposure to the space flight environment. The results of these tests not only helped in the clinical assessment of the crewman but also provided data to compare with previously acquired results on men returning from 8 days in space.

Methods and Materials

Analyses were performed on venous blood three times before the mission: 30, 12, and 2 days before lift-off (F-30, -12, -2). Postflight blood was drawn as soon possible (ASAP) after landing (L+0), 3 days later (L+3), and 10 days later (L+10). All blood samples were obtained fasting except the L+0 sample.

During the preflight and postflight periods, the crew consumed the diet of their choosing but followed the provided Shuttle diet during flight. Fluids were available when desired.

Analyses of the blood (plasma or serum) samples included: glucose (Glu), cholesterol (Chol), glutamic oxaloacetic transaminase (ALT), glutamic pyruvic transaminase (AST), blood urea nitrogen (BUN), inorganic phosphate (PO_4), bilirubin total (Bili T), creatinine (Creat), total creatine phosphokinase (CPK) and isoenzymes, total lactic dehydrogenase (LDH) and isoenzymes, osmolality (Osmol), sodium (Na), potassium (K), chloride (Cl), triglycerides (Trigly), gamma-glutamyl transpeptidase (GGTP), adrenocorticotrophic hormone (ACTH), angiotensin I (ANGIO I), aldosterone (ALDO), and cortisol. Twenty-four hour urine samples were collected 30 days before flight and on landing day. The samples were analyzed for volume, osmolality, sodium, potassium, chloride, calcium, magnesium, phosphate, uric acid, creatinine, cortisol, aldosterone, antidiuretic hormone, epinephrine and norepinephrine.

The data are given for each crewman. The preflight (PM) and standard deviation (SD) are given as the best preflight control values. Each postflight value obtained is given. The methods and established normal range for each parameter studied are given in the STS-1 Medical Report, NASA Technical Memorandum 58240.

Results and Discussion

The results show postflight decreases below preflight findings for cholesterol, osmolality, Na, and K, for both crewmen. Postflight increases above preflight values were observed in calcium, angiotensin I, aldosterone, insulin, T4, and ACTH. Alk phos., GGTP and LDH were slightly increased in the PLT postflight samples. Several parameters for the two crewmen did not change

consistently. However, these are all in areas which indicate degree of stress, state of hydration, and the immediate postflight activity prior to blood samples being acquired.

The postflight twenty-four hour urine results showed decreases in Osmo, Na, K, Cl, Mg and uric acid. Increases in excretion of cortisol, aldosterone, antidiuretic hormone and epinephrine were observed when the preflight value is compared to the first postflight value. Norepinephrine and inorganic phosphate results differed for the two crewmen.

The test results of STS-3 crewmen were similar to the findings on recovery of previous space flight crews. Table I shows the percent differences of the STS-3 crew's postflight findings compared to preflight values; the percent difference of the post- to preflight comparison for the STS-1 and STS-2 crews; the postflight findings on the Apollo crewmen who spent an average of 12 days in space compared to their preflight values; and the blood values for inflight days 3, 4 on the Skylab crewmen. This comparison leads one to the conclusion that the most dramatic changes occur and were measured within the first days of exposure to space flight. Furthermore, these findings on the Shuttle crewmen support the hypothesis that the changes in fluid and electrolyte metabolism probably occur within hours of reaching orbit as have been shown in ground simulation.

TABLE I

Parameter	Apollo Immediate Postflight % from Preflight Mean	SL Inflight Day 3,4 % from Preflight Mean	STS-1 Immediate Postflight % from Preflight Mean	STS-2 Immediate Postflight % from Preflight Mean	STS-3 Immediate Postflight % from Preflight Mean
Osmolality	-0.7	-0.6	-0.5	5.0	-1.2
Na	-0.4	-1.5	-1.0	-1.0	-2.1
K	-7.3	3.6	-6.8	-12.8	-6.2
Cl	-0.6	-0.9	-1.0	3.0	0.5
Ca	1.0	6.5	1.8	6.8	6.6
Mg	-5.0		-2.5	-4.8	8.4
PO_4	0	11.7	12.5	1.9	17.2
BUN	11.9		25.5	1.7	6.3
Creatinine	8.3	4.3	9.3	10.7	11.6
Glucose	9.8	4.2	1.0	2.6	64.2
Triglycerides	-24.3		-31.0	-32.0	9.3
Cholesterol	-6.0		-3.0	17.0	-7.5
Uric Acid	-14.8		-22.0	12.0	-10.4
Total Bilirubin	12.5		-12.5	113.0	-14.6
Alkaline Phosphatase	2.8		1.3	18.0	13.7
GGTP			19.1	33.8	16.0
Lactic Acid Dehydrogenase	-10.1		5.3	27.0	13.8
SGOT (AST)	-4.2		-14.3	-55.0	-2.0
SGPT (ALT)			0	5.9	-28.0
Creatine Phosphokinase	-11.3		-6.0	61.0	-6.8
Angiotensin I	488.0	135.3	80.0	275.0	252.7
Cortisol	-27.0	-7.5	-11.0	92.0	-17.5
Insulin	32.0	-9.1	81.0	362.0	355.1
T_3	-1.0		3.3	-5.0	9.5
T_4	12.0		11.5	31.0	17.4
TSH			-2.3	59.9	10.9
HGH	304.0	52.1	5.5	30.0	-25.0
ACTH	-24.0	-58.3	54.8	-24.0	98.9
Aldosterone		-4.7	54.8	59.9	80.1

HEMATOLOGICAL AND IMMUNOLOGICAL ANALYSES

Gerald R. Taylor, Ph.D.

Hematological and immunological analyses were conducted on the primary and backup crewmembers of STS-3 so that body-function values necessary for the objective assessment of the health status of the crew before launch and immediately after flight could be evaluated by the medical staff.

Materials and Methods

Blood samples were collected by venipuncture from the two prime crewmembers 30, 12, and 2 days before flight (F-30, F-12, F-2 respectively); within 2 hours after landing (L+0); and 3 and 10 days after landing (L+3, L+10). The backup crew was sampled 35, 11, and 3 days before flight (F-35, F-11, F-3). Cellular immunology analyses were conducted on blood collected with sodium heparin whereas Ethylene Diamine Tetra-acetic Acid (EDTA) was the anticoagulant of choice for the cellular hematology measurements. Humoral evaluations were conducted on serum from standard clot tubes. In all cases, Vacutainer (TM) tubes were used for blood collection.

Results and Discussion

The results of analyses conducted on the cellular blood components demonstrate that for the one month period preceding the flight, there were no unusual variations in the cellular blood components of the four crewmembers. However, there were important alterations in both of the primary crewmembers after flight.

Evaluation of these data demonstrate that for the one month period preceding the flight there were no unusual variations from the norm with any of the four crewmembers.

The immediate postflight values for both crewmembers indicate a loss (about 8%) in erythrocyte number when compared with the preflight mean. This should translate into a 4% change in the hematocrit which was the case with the Pilot. The postflight decrease in the hematocrit of the Commander was not as marked, owing to the greater increase in the size of the erythrocytes, as illustrated by a greater mean corpuscular volume (MCV). These data show that there was a postflight:

1) Absolute loss of erythrocyte number
2) Increase in erythrocyte volume
3) Stable hydration/dehydration state
4) Increase in corpuscular hemoglobin content (MCHC)

As has been reported for previous Shuttle flights there was a marked increase (113-116%) in the postflight white cell count. As there was no evidence of a fluid shift, this can be considered an absolute change. As with previous

flights, this increase in peripheral blood neutrophils is regarded as part of the "stress response". However, unlike other flights there was essentially no postflight change in the number of peripherally circulating lymphocytes.

Lymphocytes extracted from crew blood samples were reacted with the mitogen Phytohemagglutinin (PHA) to assess the competence of the *in vitro* immune response. After a suitable incubation period the blastogenic response was measured by determining the incorporation of radioactive thymidine into newly formed DNA. For the Commander there was a significant ($p<0.01$) postflight decrease in the ability of lymphocytes to respond to mitogenic assault. This depression had essentially returned to normal by the third day after the flight. The responsiveness of the Pilot's circulating lymphocytes was depressed two days before the flight and remained at the same low level through the last sampling period which was 10 days after completion of the mission.

MEDICAL MICROBIOLOGY OF CREWMEMBERS AND SPACECRAFT

Duane L. Pierson, Ph.D.

Crew Sample Collection

Samples were collected from each prime crewman for microbial evaulation at F-30, F-10, F-2, L+0, and L+3. The backup crew was sampled at the same designated preflight times, but no postflight samples were collected. The samples consisted of swab samples from the ears, nose, and throat; a fecal specimen (or rectal swab); and a midstream first-void urine specimen.

Spacecraft Sample Collection

Microbiology monitoring of the spacecraft was comprised of collecting and analyzing samples from the Orbiter's interior surfaces, flight hardware, air, and potable water supply.

Results and Discussion

Crew Microbiology

All crewmembers exhibited absent or normal microbial flora in ears, nose, throat, urine, and feces cultures.

Spacecraft Microbiology

Twenty-one surface sites on the mid and flight decks were sampled at F-30, F-2, and L+0. The prelaunch levels of bacterial contamination were somewhat higher than observed during STS-1 and 2. Nearly all sites exhibited higher numbers of bacteria at L+0. The number of fungi per site was low at prelaunch sampling periods. However, at L+0 almost all sites exhibited much higher levels of fungi. The F-30 sample period prior to STS-4 will be very important in assessing the cleanup procedures employed between flights.

No bacterial pathogens were isolated. However, twelve different species of the pathogenic fungal genus, Aspergillus, were isolated. Interestingly, three of these species, A. sydowi, A. phoenicis, and A. amstelodami, were isolated from the crewmen post landing. None of these species were cultured from either crewman prior to launch.

Shuttle Foods

Random samples of all foodstuffs stored onboard the Orbiter were analyzed to assure that acceptable microbial levels were not exceeded. The analytical procedures and microbiological standards have been established for both non-stabilized and thermostabilized foods. No food samples submitted to the laboratory for the STS-3 mission failed the acceptance standards.

Crew Virology

The crewmen (prime and backup) were evaluated to determine their immune status to specific viral agents. Serum samples were screened for hepatitis B surface antigen and antibody to the hepatitis A antigen at F-30, F-10, F-2, L+0 (prime crew), and L+3 (prime crew). No evidence of infection (prior or current) was found in any of the crewmen. It was determined by the Health Stabilization Officer that the crewmen had sufficient immunity (previously determined) to rubella, rubeolla, and mumps viruses to make a current evaluation unnecessary. Throat and rectal swabs were taken of the crewmen at F-10, F-2, and L+3. These specimens were evaluated for the viral agents.

Prior to the mission the prime commander was exposed by a family member to what was suspected to be Epstein-Barr (mononucleosis) virus. Serum samples were immediately examined to determine the immune status of all crewmen to EB virus. All crewman exhibited titers indicative of prior infection and were probably sufficiently immune.

FOOD AND NUTRITION

Richard L. Sauer and Rita M. Rapp

The menus for STS-3 were designed to maintain good nutrition by providing 3000 kilocalories and at least the recommended levels of nutrients listed in Table 1. Food intake records shown in Table 2 for the STS-3 Commander (CDR) from his Skylab 2 mission indicate that 3000 kilocalories per day were not a sufficient daily energy allowance for this individual. In order to assure an adequate food supply for the STS-3 CDR, additional food items were included to increase the menu allowance to approximately 4000 kilocalories per day. The supplemental foods listed in Table 3 were overwrapped, labeled by day of intended use, and stowed in locker trays with the pantry food.

Eight entry beverages were provided for fluid loading as a countermeasure to cardiovascular deconditioning. Each crewman was requested to consume four beverages prior to entry into the Earth's atmosphere. Original plans were to use Wyler's beef bouillon cubes (2.9 g/8 oz water) packaged in flight beverage containers; however, Gatorade (16 g/8 oz water) was finally selected for this purpose.

Preflight food service was provided for the STS-3 prime, backup, and support crews during countdown demonstration tests (CDDT) and the Health Stabilization period. Meals were prepared and served at both the JSC food facility and the KSC crew quarters.

Postflight food service was provided for the prime crew immediately after touchdown at Northrup Strip, New Mexico, and for the return flight to Houston.

There was no requirement to measure inflight nutrient intake; however, this was estimated after the mission. The crew ate breakfast in the crew quarters at KSC prior to launch. This meal is not included in the nutrient calculations.

The entry beverages were consumed on the day of scheduled entry prior to the time a sand storm at Northrup Strip caused a landing delay of approximately 24 hours. There were no provisions for an additional set of entry beverages. There was sufficient food in the pantry for the extra day of flight.

Table 1: Minimum Daily Nutritional Levels
Supplied by Shuttle OFT Menus

nutrient	amount
kilocalories	3,000
protein	56 gm
vitamin A	5,000 IU
vitamin D	400 IU
vitamin E	15 IU
ascorbic acid	45 mg
folacin	400 µg
niacin	18 mg
riboflavin	1.6 mg
thiamin	1.4 mg
vitamin B_6	2.0 mg
vitamin B_{12}	3.0 µg
calcium	800 mg
phophorus	800 mg
iodine	130 µg
iron	18 mg
magnesium	350 mg
zinc	15 mg
potassium	70 mEq
sodium	150 mEq

Table 2: Energy Intake for Skylab 2 PLT

Mission Phase	No. of Days	Mean Daily Kilocaloric Consumption
Preflight	21	4150
Inflight	59	3875
Postflight	18	4220

Table 3: Supplemental Food for STS-3 CDR

Day 1	No additional food	
Day 5	Peaches (T) Beef Patty (R) Turkey Tetrazzini (R) Cashews (NF)	Butter Cookies (NF) Shrimp Cocktail (R) Rice Pilaf (R)
Day 2, 6	Eggs (R) Potato Patty (R)	Meat Balls w/BBQ (T) Pecan Cookies (NF)
Day 3, 7	Chicken a la King (T) Cashews (NF) Fruitcake (NF)	Rice Pilaf (R) Strawberries (R)
Day 4	Eggs (R) Apricots (NF) Breakfast Roll (NF)	Potato Patty (R) Turkey α Gravy (T) Peas w/Butter Sauce (R)
Day 8	Apricots (NF) Breakfast Roll (NF)	

THE POTABLE WATER

Richard L. Sauer

The Potable Water System performed without difficulties throughout the third Shuttle mission. The problem of air in the water, noticed on STS-2, did not occur during STS-3.

Results and Discussion

A total of twelve chemical and nine microbiological samples were taken from the potable water system for STS-3. The specific parameters tested for are those listed in Tables 1 and 2. All parameters of medical concern met the specification limits with the exception of those listed below. Parameters of nonmedical concern exceeding the specification limits were total solids (10mg/l max), total organic solids/carbon (3.1mg/l max), and color (> 50 units).

- Nickel - The water initially used to service the water system for STS-3 exceeded the 0.05mg/l limit for nickel. The maximum level of nickel detected preflight (0.15mg/l) does not represent a health hazard. Nickel levels postflight were within specification limits.

- Dissolved Gas - Dissolved gas was detected in the Ground Support Equipment (GSE) water used to service the vehicle. Subsequent samples were free from dissolved gas.

- Taste and Odor - A slight iodine taste and odor was detected. The levels were very low and of no medical consequence. The taste and odor were due to the iodine concentration within the potable water storage tank. The crew receives water from the water dispenser which strips iodine concentrations to a maximum of 0.4mg/l. Taste and odor of iodine would not be detectable at this level.

- Total Bacteria - Total bacteria exceeded the specification limit of zero up to a maximum of 91 colony forming units per 100ml (CFU/100ml) and 32.6CFU/100ml in the ambient and chilled water samples, respectively. While exceeding the limit, these levels are not considered significant. The organisms were identified as Flavobacterium, Enterobacter, and Pseudomonas, all being common contaminants of water, but none considered pathogens under these conditions.

- Yeast and Mold - One ambient water sample exceeded the yeast and mold specification limit of zero. The level detected was 1.3CFU/100ml. The yeast was identified as Rhodotorula minuta var. texensis. Rhodotorula minuta has not been shown to be a pathogen.

The Shuttle Potable Water System provided the STS-3 crew with water that was acceptable for both metabolic and hygenic needs. Although not a medical concern, postflight iodine levels were somewhat higher than expected. The crew was not exposed to these levels since the water dispenser strips iodine to a maximum of 0.4mg/l. The Potable Water System functioned without problems throughout STS-3.

TABLE 1

PREFLIGHT STS-3 POTABLE WATER ANALYSIS (TANK A)
REF. SE-S-0073C-TABLE 6.4.6

Parameter	Units	Ref. Limit	3/19/82 JSC#1 Ambient	3/19/82 JSC #1 Chilled	3/22/82
Conductivity	µmho	-	-	-	
pH	pH	-	-	-	
Total Solids	mg/l 2-Amb/10	Chilled	-	-	
Total Org Solids/Carbon	mg/l	-	-	-	
Taste and Odor	-	*	-	-	
Turbidity	NTU	11 max	-	-	
True Color	Units	15 max	-	-	
Cadmium	mg/l	0.01 max	-	-	
Chromium (hexavalent)	mg/l	0.05 max	-	-	
Copper	mg/l	1.0 max	-	-	
Iron	mg/l	0.3 max	-	-	
Lead	mg/l	0.05 max	-	-	
Manganese	mg/l	0.05 max	-	-	
Mercury	mg/l	0.005 max	-	-	
Nickel	mg/l	0.05 max	-	-	
Selenium	mg/l	0.01 max	-	-	
Silver	mg/l	0.1 max	-	-	
Zinc	mg/l	5.0 max	-	-	
Dissolved Gas @31°C	+	None	N/A	N/A	
Iodine	mg/l	-			
Total Coliform Bacteria	#/100ml	0	0	0	
Total Bacteria	#/100ml	0	4.6[B]	32.6[B]	
Anaerobes	+	0	0	0	
Yeast and Mold	#/100ml	0	1.3[C]	0	

LAUNCH

*None at threshold, no. of 3.
B. Flavobacterium and Pseudomonas.
C. Rhodotorula minuta var. texensis.

TABLE 2

POSTFLIGHT STS-3 POTABLE WATER ANALYSIS (TANK A)
REF. SE-S-0073C-TABLE 6.4.6

Parameter	Units	Ref. Limit	Date → 4/2/82 Postflt Sample → Port → Ambient WSTF	4/2/82 Postflt Chilled WSTF	4/2/82 Postflt Ambient JSC	4/2/82 Postflt Chilled JSC	4/2/82 Postflt Ambient KSC	4/2/82 Postflt Chilled KSC
Conductivity	µmho	-	4.0	4.6	6.8	8.3	-	-
pH	pH	-	4.7	4.6	4.7	4.6	-	-
Total Solids	mg/l 2-Amb/10	Chilled	-	-	10	1.0	2.1	<2.0
Total Org Solids/Carbon	mg/l	-	-	-	-	-	-	-
Taste and Odor	-	*	-	-	D	E	None	None
Turbidity	NTU	11 max	-	-	-	-	<11	<11
True Color	Units	15 max	-	-	50	50	>15	>15
Cadmium	mg/l	0.01 max	-	-	<0.01	<0.01	<0.01	<0.01
Chromium (hexavalent)	mg/l	0.05 max	-	-	<0.05	<0.05	<0.05	<0.05
Copper	mg/l	1.0 max	-	-	<1.0	<1.0	<1.0	<1.0
Iron	mg/l	0.3 max	-	-	<0.3	<0.3	<0.3	<0.3
Lead	mg/l	0.05 max	-	-	<0.05	<0.05	<0.05	<0.05
Manganese	mg/l	0.05 max	-	-	<0.05	<0.05	<0.05	<0.05
Mercury	mg/l	0.005 max	-	-	<0.005	<0.005	<0.005	<0.005
Nickel	mg/l	0.05 max	-	-	<0.05	<0.05	<0.05	<0.05
Selenium	mg/l	0.01 max	-	-	-	-	<0.01	<0.01
Silver	mg/l	0.1 max	-	-	<0.05	<0.05	<0.1	<0.1
Zinc	mg/l	5.0 max	-	-	<5.0	<5.0	<5.0	<5.0
Dissolved Gas @31°C	+	None	None	None	N/A	N/A	N/A	N/A
Iodine	mg/l	-	4.7	5.4	7.0	7.4	N/A	N/A
Total Coliform Bacteria	#/100ml	0	-	-	-	-	0	0
Total Bacteria	#/100ml	0	-	-	-	-	91 F,G	3F
Anaerobes	+	0	-	-	-	-	0	0
Yeast and Mold	#/100ml	0	-	-	-	-	0	0

*None at threshold, no. of 3.
D. Chlorine taste; odor #4.
E. Chlorine taste; odor #17.
F. Pseudomonas cepacia.
G. Pseudomonas alcaligenes, one Enterobacter.

SHUTTLE TOXICOLOGY

Wayland J. Rippstein

An atmospheric sampling program is conducted to characterize the outgassing behavior of the Orbiter.

Since an unusually high level of toluene was detected in atmospheric samples returned from the STS-2 mission, two preflight samples were collected for STS-3. These were collected at the Kennedy Space Center (KSC) two weeks prior to the STS-3 launch. Four atmospheric sampling cylinders were carried onboard STS-3 for inflight sampling purposes. The STS-3 crew collected samples just after attaining orbit; just prior to deorbit; and on two occassions, equally spaced, between the first and last sampling times.

Table 1 contains the analytical results of the two cabin atmospheric samples taken just prior to the STS-3 launch. The main reason for taking these samples was to determine whether the toluene detected in the STS-2 mission was still present at an elevated value. Toluene was detected in sample number 2, but was present at a concentration of only 0.001 parts per million (ppm). This level is of no consequence. Methane was present at 1.67 ppm and offered no problem. The remaining 12 compounds were all well below the one part per million level.

The only compounds present in concentrations greater than one part per million were:

Compound	Cabin Concentration	SMAC* Value
1. carbon monoxide	2.28 ppm	25 ppm
2. methane	7.54 ppm	2700 ppm
3. bromotrifluoromethane (Halon 1301)	2.67 ppm	100 ppm
4. ethanol	1.21 ppm	50 ppm

*SMAC = spacecraft maximum allowable concentration.

The remaining 36 compounds were below the one part per million concentration range. Evaluation of the 40 compounds using the toxicity group categories method indicated no hazard.

The results from the analyses of the two samples taken just prior to the STS-3 mission proved that the Orbiter cabin had been cleaned of the toluene detected during the STS-3 mission. This may be accounted for by the new restrictions imposed on the use of solvents in the cabin prior to the launch period.

The results from the analyses of the four samples taken during the STS-3 mission indicated the presence of 40 compounds. Four of these compounds were present in concentrations above 1 part per million.

This is the first time that carbon monoxide reached the 2.28 ppm level. The SMAC value for carbon monoxide is 25 ppm. STS-2 carbon monoxide stayed below 1 ppm while STS-2 carbon monoxide attained a high value of 1.02 ppm.

Halon 1301 was found in the last sample taken during the STS-3 mission at 2.67 ppm. It was learned from the debriefing records that one of the Orbiter's hand held fire extinguishing devices had been purposely discharged into an avionics bay area during the mission.

In conclusion, the STS-3 cabin atmosphere presented no toxic hazard during the mission. It is also noteworthy to point out that the crew did not indicate any odor problem during the STS-3 mission.

TABLE 1

STS-3 PREFLIGHT ATMOSPHERIC ANALYSIS[a]

COMPOUND	SAMPLE 1	SAMPLE 2
Trichlorofluoromethane	0.939 (0.167)	1.709 (0.304)
1,1,2-Trichloro-1,2,2-Trifluorethane	0.284 (0.037)	1.020 (0.133)
Ethanal		0.189 (0.105)
Propanal		0.014 (0.006)
2-Propanone	<0.002 (<0.001)	0.007 (0.003)
Butanal		0.026 (0.009)
2-Butanone		0.006 (0.002)
1,1,1-Trichloroethane	0.005 (0.001)	0.016 (0.003)
Dichloromethane	0.031 (0.009)	0.059 (0.017)
2-Propanol		0.005 (0.002)
Benzene	<0.003 (<0.001)	<0.003 (<0.001)
Toluene		<0.004 (<0.001)
Carbon Monoxide	<0.057 (0.05)	1.067 (1.631)
Methane	1.091 (1.668)	1.067 (1.631)

[a]Concentrations are in mg/m^3, values in parentheses are in ppm.

RADIOLOGICAL HEALTH

Robert G. Richmond and B.L. Cash

Manned spaceflight results in exposure of astronauts to a radiation environment that is significantly more complex than that normally associated with the radiological health environment for industrial workers.

A record of all radiation exposure received by the astronauts is maintained as part of the astronaut's medical record. The measured dose of radiation encountered by the space crew during each mission is added to the individual crewman's medical record.

Permissible radiation exposures are provided for each mission on a risk versus gain basis by the JSC Radiation Constraints Panel. These exposure limits are entered into the Flight Rules which are used to govern the mission. The basis for radiation protection standards for space flight is provided in guidance by the National Academy of Sciences.

A constant watch is maintained to project the incidence of potentially hazardous radiation conditions which might occur during the mission. In cooperation with the National Oceanic and Atmospheric Administration and the Department of Defense, constant evaluation of space environment is conducted.

The results from the radiation instrumentation measurements aboard the Columbia, STS-3, March 22-30, 1982, are presented in Table 1. This report includes measurements from the crew pocket dosimeters (CPD: low range, high range, and high rate), the unshielded thermoluminescent dosimeters (TLD). An examination of the high energy-high atomic number (HZE) plastic detector stacks was conducted although the data will not be presented here.

The dosimeters were placed in pouches which were stowed on the spacecraft. The Crew Activities Plan (CAP) called for the dosimeters to be deployed throughout the spacecraft at L+8 hours.

Prior to the mission, background readings for each instrument were taken and the procedure developed for extrapolating a value for the background at the time of the postflight readout. This procedure was implemented as planned. Data from the six low-range pocket dosimeters are presented in Table 1. These data represent the corrected "flight doses", i.e., the dose attributed to the spaceflight alone. The background correction that has been made consists of: (1) residual charge imparted to the unit when zeroing it; (2) the leakage of the charge with time; and (3) the recording of the naturally-occurring radiation background.

The measured doses from the CPD's are given in Table 1. The average flight dose measured with the CPD's was 46.1 $\pm$ 2.6 mRem. The CPD's worn by the backup commander and pilot were used to provide background corrections for the CPD's worn by the commander and pilot. The averages of the two control CPD doses were used to provide a background subtraction for the other flight units.

TABLE 1. SUMMARY OF RADIATION MEASUREMENTS FOR STS-3

MEASUREMENT	LOCATION	TLD DOSE (mRem) TLD-200	TLD DOSE (mRem) TLD-700	POCKET DOSIMETER DOSE (mRoentgen)
COMMANDER	IN CLOTHING	41.5	47.1	NONE WORN
PILOT	IN CLOTHING	45.0	45.9	NONE WORN
POUCH 1	ON AIRLOCK, ABOVE HATCH	48.7	49.0	57 ± 3
POUCH 2	ON OUTER WALL, BEHIND & AFT DFI	46.1	46.2	48 ± 3
POUCH 3	OUTER WALL, ABOVE INGRESS/EGRESS HATCH	40.7	44.4	53 ± 3
POUCH 4	AFT, TOWARD OF OBSERVATION WINDOW	46.1	50.2	56 ± 3
POUCH 5	ON CLOSEOUT PANEL, ABOVE LOCKER L-10	50.4	44.4	55 ± 3
POUCH 6	ON CLOSEOUT PANEL, ABOVE LOCKER R-11	45.2	46.0	58 ± 3

ENVIRONMENTAL EFFECTS OF SHUTTLE LAUNCH AND LANDING

Andrew Potter, Ph.D.

The environmental effects of the exhaust cloud produced by the launch of STS-3 were monitored at the Kennedy Space Center (KSC), Florida. Acidic mist and dust from the cloud were the main focus. The monitoring program contained the following elements:

- Exhaust cloud model, used to predict height and direction of the cloud and surface concentrations of dust and HCl.
- Monitoring stations, each including pH paper, copper plates, HCl dosimeter tubes, and a nucleopore filter.
- Geomet units for gaseous HCl measurement.
- Air quality measurements (O_3, SO_2, etc.) prior to and during launch.
- Acoustic noise measurement.
- Cloud photography.
- Aircraft sampling of cloud particles.
- Post-flight water, sediment and soil analyses of samples near the pad.
- Survey of benthic organisms on lagoons near the pad before and after launch.
- Survey of vegetation before and after launch.

Results and Discussion

Launch Exhaust Cloud Dynamics

STS-3 was launched at Cape Canaveral, Florida, on March 22, 1982, at 10:00 a.m. EST. The weather conditions at launch were partly cloudy skies with surface winds out of the southwest (240^{o}) at 3 knots. The surface temperature was $26.1^{o}C$, with the relative humidity at 66%. The launch generated a cloud of exhaust products which moved out to sea. The cloud was composed of aluminum oxide dust, liquid HCl aerosol, and gaseous HCl, plus a small amount of dust swept up from the launch area. The launch cloud was observed and video taped from the CIF Antenna Building, from which vantage point it appeared to split into two parts at launch. One part traveled north from the flame trench and went out to sea in a northeasterly direction. The second part went south for about one kilometer and then traveled east out to sea. An additional video tape recording of the cloud was made from UCS6, near the Vehicle Assembly Building (VAB), and this recording indicated a similar cloud pattern. A third recording made from the Wildlife Laboratory area, just south of Haulover Canal, was of little value due to the poor visibility at this site. Airborne observers also noted that the cloud split into two components, one at 1000 ft.

and the other at about 2000 ft. Both ground-based and airborne measurements were made of the cloud. Ground-based measurements were limited, since the cloud traveled over land only a short distance before going out to sea. Airborne measurements followed the cloud for about 35 miles.

Surface Measurements Plan

The measurement plan for STS-3 differed from STS-1 and STS-2, in that it was reduced in scope, with most of the measurement sites determined from cloud model predictions prior to the launch, rather than at fixed locations. Measurements were made of gaseous HCl, atmospheric particulates, acidic mist and dust deposition, biological impacts, temperature and acoustic noise. Particle size distributions, wind velocity and temperature were measured in the exhaust plume at the north edge of the launch pad. Video recordings as well as still photographs were made of the launch and exhaust cloud from several vantage points.

Effect of the Launch Cloud on the Surface

Since the cloud traveled quickly out to sea, the surface measurements were confined to the pad area and the region between the pad and the beach.

The HCl dosimeter and HCl geomet data were not available at the time of this report. However, the reaction of pH paper and copper plates at the pad sites is indicative of the HCl levels at these sites. The pH paper showed bits of droplets with pH values less than 1, and the copper plates were blackened from exposure to HCl with pH values less than 1.

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15. Supplementary Notes

16. Abstract

The medical operations report for STS-3, which includes a review of the health of the crew before, during, and immediately after the third Shuttle orbital flight (March 22-30, 1982) is presented. Areas reviewed include: health evaluation; medical debriefing of crewmembers; health stabilization program; medical training; medical "kit" carried in flight; tests and countermeasures for space motion sickness; cardiovascular profile; biochemistry and endocrinology results; hematology and immunology analyses; medical microbiology; food and nutrition; potable water; Shuttle toxicology; radiological health; cabin acoustical noise. Also included is information on: environmental effects of Shuttle launch and landing, medical information management; and management, planning, and implementation of the medical program.

17. Key Words (Suggested by Author(s)

Toxicology
Acoustic Noise
Medical Science
Management, Planning
Medicine
Cardiovascular System
Training Simulators
Biochemistry/Endocrinology
Food
Radiation Hazards
Environmental Effects
Nutrition
Crews (Health)
Motion Sickness
Water
Hematology/Immunology
Microbiology

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